COMPARISON OF NITROGEN AND ARGON PLASMA IMMERSION ION IMPLANTATION (AND DEPOSITION) INSIDE AND OUTSIDE STAINLESS STEEL 304 TUBES

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1. Introduction

Hollow cathode discharge has been employed in a wide variety of applications: plasma immersion ion implantation in tubes, surface modification and deposition of thin film, space propulsion, basic plasma research, nitriding, among others [1]. Recently, surface treatments have been carried out using hollow cathode discharges as a plasma source due to the better plasma confinement and its higher density [2].

In this work, a comparison of nitrogen and argon plasma immersion ion implantation in tubes of stainless steel 304 was carried out, in order to investigate the influence of working gas in the treatment.

2. Experimental

For the present PIII processing, hollow cathode configurations were chosen for the experiments using stainless steel 304 tubes with 11.0 and 4.0 cm diameter and 20.0 cm of length. In these configurations, a sample support (ss) placed at 10.0 cm distance from the tube was used. Samples of stainless steel 304 and silicon wafer were placed inside and on the top of tube, as well as and on the ss.

Argon ion bombardment was used previous to the treatment of the samples surface for their cleaning, during 10 minutes and then, the nitrogen or argon implantation was carried out for up to 120 minutes.

3. Results and Discussions

The analyses of elemental depth profiles obtained after the treatment using the ss placed at 10.0 cm of distance from the tube (11.0 cm diameter) allowed to verify that the maximum depth of nitrogen ion implantation was 43.0 nm with nitrogen peak at 26.0 at.% in silicon sample placed at the ss, as shown in Fig. 1. However, residual oxygen can be observed in large amount on the surface of the Si sample. When there is such an elevated percentage of oxygen present on the surface of SS304 during the N-PIII, strong segregation of nickel should occur [3]. Indeed, that phenomenon can be verified in this case. In the standard stainless steel samples, the elements composing it show stoichiometric iron compared with other elements that are Cr, Ni, Mn, Si and C. Due to this fact, it was verified by a TRIM simulation code that the sputtering rate will also follow the stoichiometric ratio.

Figure 2 shows the depth profiles in silicon sample treated by Ar-PIII, and it can be observed a great percentage of iron (35.0 at.%) but the atomic percentage of chromium is around zero whereas that of nickel is 14.0 at.%. Using the argon as working gas, the nickel segregation was not observed any more, although a high oxygen concentration was measured on the surface of silicon sample. It was observed that chromium was present in low atomic percentage instead (chromium segregation).

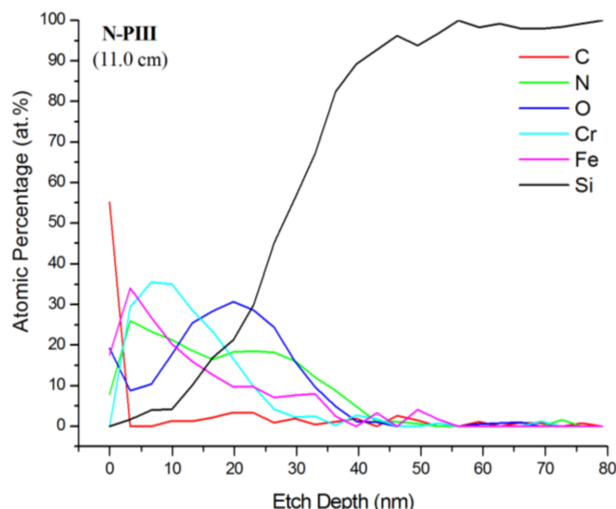

Fig. 1. *Elemental depth profile obtained by Auger Electron Spectroscopy (AES) of silicon sample treated with N-PIII.*

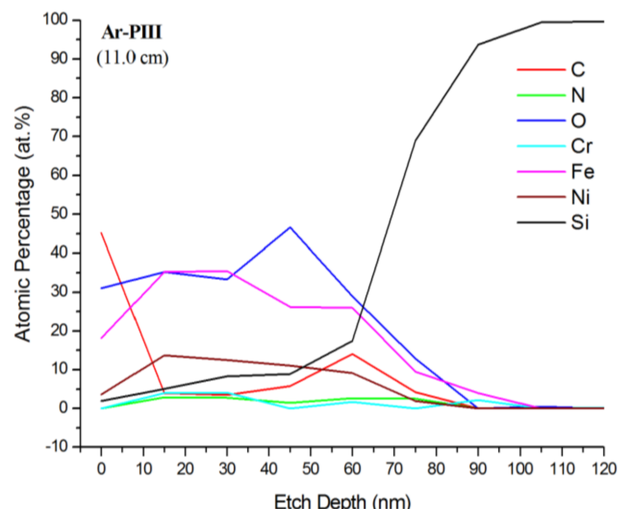

Fig. 2. *Elemental depth profile obtained by Auger Electron Spectroscopy (AES) of silicon sample treated with Ar-PIII.*

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The X-Ray Diffraction data obtained allow us to verify the formation of expanded austenite in sample treated with N-PIII. On the other hand, in the samples treated by Ar-PIII, it was observed the formation of FeO. These phase and compound formations were observed only in the samples placed inside the tube. In the samples placed on the top of the tube and at the ss no phase or compounds were formed.

Results obtained in other tube diameters, will be presented at the conference with results of XRD, FEG, EDS, among others.

4. References

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